

# Atomic Parity Nonconservation in Stable Ytterbium Isotopes

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Atomic parity nonconservation (PNC) experiments provide a valuable test of our understanding of both semi-leptonic and purely hadronic weak interactions. Parity-nonconserving weak interactions within the atom result in small modifications in the atom's optical properties. By observing these PNC-induced effects it is possible to make a low-energy quantitative test of the Standard Model of electroweak interactions and to study parity-nonconserving effects within the nucleus.

The  $6s^2\ ^1S_0 \rightarrow 6s5d\ ^3D_1$  transition in atomic Yb is a promising system for the study of PNC [1]. In the absence of PNC effects, the electric-dipole (E1) transition amplitude is strictly forbidden by the parity selection rule, while the magnetic-dipole (M1) amplitude is highly suppressed. The application of an external electric field mixes even- and odd-parity states, giving rise to a Stark-induced amplitude ( $E1_{St}$ ). The weak interaction also mixes even- and odd-parity states, giving rise to a parity-nonconserving transition amplitude ( $E1_{PNC}$ ). In order to measure the very small  $E1_{PNC}$ , one observes the interference between the much larger  $E1_{St}$  and  $E1_{PNC}$ , as one excites this forbidden transition with intense laser light. The parity-nonconserving effect in Yb is expected to be very large, due to the presence of two energetically nearby states of opposite parity.

Comparing PNC effects in several stable isotopes of Yb will allow us to extract fundamental information about the weak interaction independent of atomic structure calculations. In addition, comparison of PNC effects in the different hyperfine components of the two isotopes of Yb that have non-zero nuclear spin will allow for a determination of the nuclear anapole moment, a key quantity in improving our understanding of hadronic PNC effects within the nucleus.

In the past year we have seen the publication of our measurement of the highly forbidden M1 transition amplitude for the  $6s^2\ ^1S_0 \rightarrow 6s5d\ ^3D_1$  transition through the method of Stark interference [2]. This quantity is important in understanding possible systematic errors for future PNC results. The measured value is

$$|\langle ^3D_1 | M1 | ^1S_0 \rangle| = 1.33(6)_{Stat}(20)_\beta \times 10^{-4} \mu_0,$$

where the second error represents the uncertainty in the

determination of the Stark-induced amplitude  $\beta$ . The size of the M1 amplitude should not limit the precision of a PNC experiment.

We have also continued the development of the high-finesse ( $\mathcal{F} = 5000$ ) confocal power-build-up cavity required for the PNC experiment. The build-up cavity will increase our statistical sensitivity and reduce certain systematic effects; allowing us to make a measurement of the PNC-induced transition amplitude to a fractional experimental precision of  $\lesssim 1\%$ . We have implemented a high-bandwidth feedback system utilizing an intra-cavity electro-optic modulator to lock the laser frequency to the resonance of the power-build-up cavity. We have also begun developing a positioning stabilization system which will allow us to couple light from the laser table into the power-build-up cavity inside the vacuum chamber. Implementation of the power-build-up cavity and the associated laser stabilization and locking represent some of the largest technical challenges of the PNC experiment.

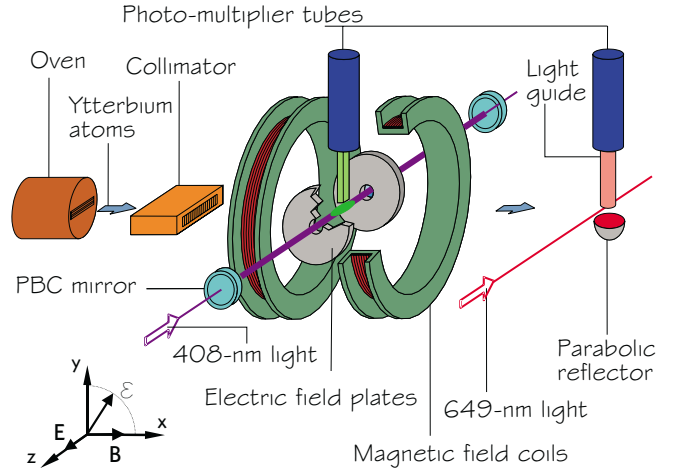


FIG. 1: Experimental apparatus for the PNC experiment.

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